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CTIOA Field Report 84-2-2

SUBJECT: WORKING WITH PORTLAND CEMENT CONCRETE

I. INTRODUCTION

A. Concrete, like many other products, has many faces.

B. There are many types of concrete, ranging from highly air entrained lightweight concrete to very dense, high compression strength structural concrete. Concrete can be formed, poured in place, tilt up,-prestressed or post tensioned.

C. Not all concrete is suitable to bond ceramic tile directly to.

D. The purpose of this report is to ask and answer many questions concerning the relationship between tile and concrete. Ceramic Tile ANSI Specifications and the handbook have many references to concrete and concrete finishes and treatments It is imperative that the concrete trade is in agreement with what the documents of the tile trade say about concrete.

E. The questions and answers were prepared by the Ceramic Tile Institute in conjunction with Mr. Robert T. Barclay, P.E., of the Portland Cement Association.

II. DISCUSSION

- AQ: The ceramic tile trades ANSI Books have references to concrete and concrete finishes. Are our references compatible with the concrete trade's standards and practices? The ANSI Standards call for concrete slabs that are to receive ceramic tile bonded directly to them, to have the concrete surface given a steel trowel and fine broom finished; any problems with this?
- AA: This type of finish is permitted within standard concrete practices. However, it is not generally used where close AA tolerances (1/8" in 10') have been specified. It would be most helpful to spell out in the concrete section the need for a fine broom finish for concrete that is to receive tile in the thin set method. If the broom finish is not specifically called out, then it would be customary in all close tolerance concrete to be rotary trowel finished.
- BQ: The Handbook for Ceramic Tile Installation also has references to

concrete and they need to be evaluated.

- BA: The Handbook references concrete placed on grade and above grade. Any of the referenced details are suitable for slab on grade construction. Bonding tile to structural slabs on slab above grade is another matter. Generally, slabs above grade are designed to move or flex. They must accomodate live and dead loads, seismic movement and normal structural movement.

  For these reasons, it is not wise to bond a rigid tile surface to a structural concrete slab. In general, detail F111 from the Handbook shows an acceptable method of installing tile on slab above grade. If tile must be installed directly on slab above grade, we would recommend that a trowel on latex based membrane be applied to the concrete surface prior to installing the tile. This will allow the installation some degree of movement and will help prevent minor slab cracking from transferring through to the tile.

  We are saying no curing compounds for curing the concrete. What problems does this cause the concrete trade? What are the other options for curing the concrete, how practical are the options for curing, how cost-effective are they, and what potential problems do they present?

  Concrete must be cured to assure proper strength gain, lessen the chance of excessive cracking, and reduce surface imperfections. There are, however, other means of curing concrete other than using curing compounds. The simplest and most economical is to water cure the slab using polyethylene sheeting to cover the slab. Care must be taken to seal the edges so as not to allow the water to escape.

  Where curing compounds are used for above grade slabs because it is not feasible to water cure, it must be specified that the slab be machine scarified or sandblasted prior to installing tile. If the slab is not properly scarified, the curing compound will create a very poor bond between tile and concrete.

- DQ: The ANSI Book and Handbook recommend expansion joints. Are our requirements for expansion joints compatible with those used in the concrete trade?

  In concrete construction, the joints that ANSI calls expansion joints are in reality isolation or contraction joints. For concrete slab-on-grade the placement of contraction joints would depend on whether the slab contained steel or wire reinforcing or not. If the slab is unreinforced, the joints should be placed no farther apart than 15' on center in both directions. If the slab is reinforced, the joints should be placed at a maximum of 20' on center in both directions.

  Editors Note: The Ceramic Tile Institute recommends that wherever tile is to be installed over concrete the slab must be reinforced.

  The ANSI requirements are 16' on center in both directions for exterior installations and 24' to 36' on center for interior installations. It must be noted that wherever a joint appears in the concrete it must be continuous through the tile. For structural slabs, the joints must be designed by the engineer. Regardless of joint placement in the structural slab, the tile must have joints the depth of the tile and mortar at the required intervals.

  Editors Note: All joints designed into the concrete slab must be brought completely through the tile installation. If the spacing of these joints is not

sufficient for tile, then additional joints should be added.

- EQ: The ANSI Book and Handbook recommends certain tolerances for trueness of plane for concrete surfaces. Are these tolerances practical? If the concrete is off plane, how can it best be corrected? What type of underlayments are satisfactory? How to apply it?

- EA: The surface tolerances of concrete in the ANSI Standards are compatible with the American Concrete Institute's (ACI) standards for cast-in-place concrete walls and floors.

  The ANSI Standard's tolerance for floors is noted in ACI 302, Guide for Concrete Floor And Slab Construction, as a class AA finish. Since this is the highest tolerance that can be specified, do not specify it unless you really need it. The cost of this finish is naturally higher than a finish that has lesser finishing tolerances. If the concrete is out of plane, hopefully, it can be taken up with the bonding mortar to be used with the tile.

  Should the deviation exceed 1/8", a self-leveling cementitious underlayment may be used to correct the uneven surface plane. These underlayments are liquid applied normally after a primer has been applied to the substrate. Prior to applying these underlayments, they should be checked as to their compatibility with ceramic tile.

- FQ: Are certain types of concrete or certain compressive strengths of concrete better for tile installations?

- FA: Concrete of the lowest possible slump should be used in all cases. The lower the slump of a particular mix of concrete, the less the shrinkage will be for that mix. Naturally, the less the shrinkage the less cracking will occur. Another factor to consider is the thickness of the concrete substrate.

  By increasing a concrete slab on grade from 4^{11} to 5^{11}, 25% more concrete is used but the flexure strength of the 5" section is 56% stronger than the 4" section. Higher compressive strength concrete is better for tile installation. The higher the compressive strength rating, the less the concrete will shrink and crack.

- GQ: What information is available for specifying the types of concrete over which tile is going?

  There are several publications offered by the Portland Cement Association and the American Concrete Institute regarding the proper construction, mixing and placement of concrete slabs With respect to literature published by the concrete industry on slab preparation for ceramic tile, there is very little. It would be best to simply call out the necessary requirements in the concrete section as well as the tile section of the specifications.

  Is structural lightweight concrete suitable for a substrate over which ceramic tile is to be installed?

  Yes, structural lightweight concrete is suitable for a substrate to receive tile. There is a difference between structural lightweight concrete and highly air entrained foam concrete.

  It would not be recommended to install ceramic tile over low density lightweight concrete even on on-grade installations. This type of low density

concrete can be dimensionally unstable and does not have a surface which provides a good bond.

It should also be pointed out that structural concrete should be treated the same as regular concrete as far as deflection tolerances, surface preparation and expansion joints are concerned.

- IQ: Efflorescence from concrete, can it be prevented? Controlled?
- IA: Efflorescence is a condition created by water percolating through concrete or masonry. The water attracts the soluble salts and transmits them to the surface. At that point, the water evaporates and the salts are left behind as a chalky white mineral residue. Efflorescence cannot start or be maintained without water. Therefore, if the water can be stopped or minimized, then efflorescence will be stopped or greatly reduced. Water percolation through the slab can be greatly reduced by placing the slab over a 6" to 8" layer of one inch rock. Proper waterproof membranes and adequate slope to drains are also effective ways of minimizing efflorescence.
- JQ: What type of reinforcing is best for concrete slabs to resist cracking?
- JA: Reinforcing bar and welded wire mesh are acceptable for use in concrete slab construction. These reinforcing materials will, if placed properly, reduce shrinkage and cracking. Reinforcing bar usually provides better reinforcing because of the way it must be placed. Ideally, the reinforcing should be placed one third of the way down from the top of the slab.
- KQ: Post tensioned concrete, prestressed concrete; are they suitable as the concrete substrate? For which installation or installations? F111, F112, F113?
- KA: Prestressed or post tensioned concrete are acceptable substrates to receive tile. If in an above grade installation, the best recommendation would be to isolate from the concrete as depicted in detail F111 of the Handbook For The Installation Of Ceramic Tile. If tile must be adhered directly to the slab, then a flexible latex based membrane should be placed over the slab prior to installing the tile.

III. CONCLUSION

A. Concrete, by and large, is an unstable material. During it's curing process, it will shrink significantly. If this shrinkage has not been provided for in the form of expansion/ contraction joints, the concrete will surely crack. If tile is bonded to the concrete, it too will crack. For this reason, the Ceramic Tile Institute would recommend that whenever possible, the tile should be installed on a wire reinforced mortar bed isolated from the concrete slab by a cleavage membrane.

B. Our second best installation recommendation is to apply a trowel on multi-layer fiberglass mat reinforced latex base membrane. This membrane, properly installed, will not only provide a waterproof installation, but the membrane will also have the ability to span minor cracking without cracking the tile.

C. If ceramic tile must be bonded directly to the concrete slab, the following recommendations are highly advisable, if not in some cases, mandatory under the National Standards.

1. Concrete to be well cured, minimum 28 day wait prior to installation of tile.
2. Concrete to be water cured whenever possible. If curing compounds are used, concrete surface must be sandblasted

3. Specify a concrete with the lowest possible slump to reduce shrinkage and cracking.

D. To reduce the risk of efflorescence in slab-on-grade concrete, place the concrete slab over a 6" to 8" layer of 1" rock to promote drainage and cut down on the capillary action of the concrete.

1. Expansion joints should be specified 20' on center for reinforced concrete. All joints in the concrete should be brought through the tile surface and filled with a proper elastomeric sealant. If additional joints are needed, they should be placed through the entire tile installation.

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